Supporting information for:

Enhanced light harvesting in mesoporous TiO_2/P3HT hybrid solar cells using a porphyrin dye

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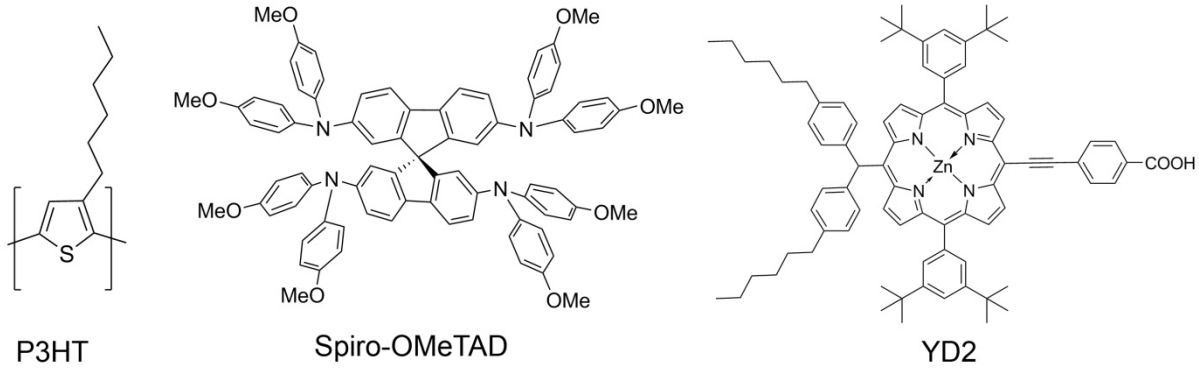

Fig. S1. The molecular structures of the P3HT, Spiro-OMeTAD and YD2 are shown.

Table S1. Photovoltaic performance of YD2 sensitized cells with Spiro-OMeTAD and P3HT. Measured under AM1.5 conditions, 100 mW/cm^2. (0.20 cm^2 of masked active area)

Device	J_{sc} **(mA/cm^2)**	V_{oc} **(mV)**	***F.F.***	η **(%)**
TiO_2/P3HT	2.12	425	0.53	0.49
TiO_2/YD2/P3HT	12.1	510	0.50	3.13
TiO_2/YD2/P3HT (duplicate)	10.62	534	0.53	3.03
TiO_2/YD2/Spiro-OMeTAD	2.56	827	0.77	1.64

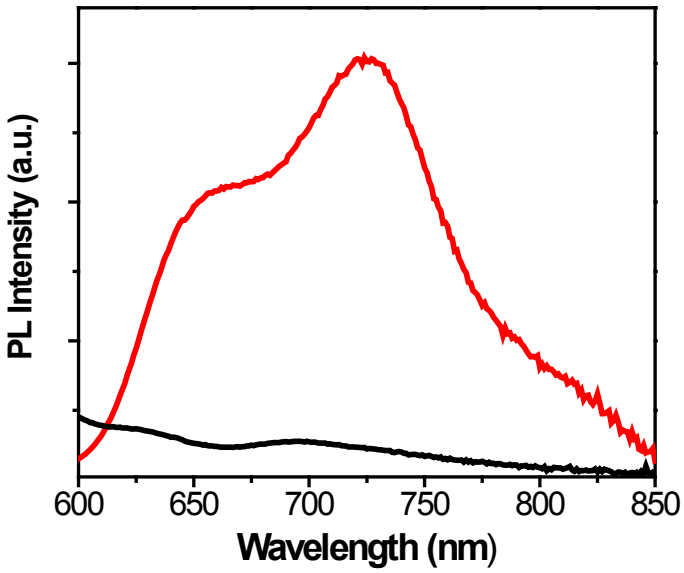

Fig. S2. Photoluminescence spectra of the pristine P3HT film (red) and P3HT/YD2 mixture (black).

Device fabrication details:

The fabrication of our hybrid solar cells employed a F-doped SnO_2 glass substrate (15Ω/□, Pilkington) onto which a ~100 nm compact TiO_2 layer was deposited by spray pyrolysis.[1] Since P3HT is known to have difficulties infiltrating the 20 nm pores traditionally used in TiO_2-based solar cells,[2] we prepared our mesoporous TiO_2 layer with larger particles and larger pores. A layer about 1 µm thick with 75 nm TiO_2 particles was coated onto the FTO/compact TiO_2 substrate using the spin coater. The 75 nm powder was received from Showa Titanium Co., and the TiO_2 paste was prepared using a previously reported procedure.[3] The electrode was then annealed at 500 °C for 30 min under oxygen flow, followed by treatment with a 0.02 M $TiCl_4$ aqueous solution for 6 hours at room temperature. It was re-annealed at 450˚C in air for 30 min and cooled before immersing it into a YD2 dye solution (0.2 mM in ethanol with 0.4 mM chenodeoxycholic acid to prevent aggregation[4]) for 18 hours. The dye coated TiO_2 electrodes were spin-coated at 250 rpm for 500 sec with a regioregular-P3HT solution (Reike Metals Co. 30 mg/ml in chlorobenzene). A poly(3,4-ethylenedioxythiophene): poly(styrenesulfonate) (PEDOT:PSS) solution (2.8 wt% dispersion in water, Baytron P) diluted with two volumes of MeOH was spin-coated onto the TiO_2/YD2/P3HT films at 2000 rpm for 30 sec. As a counter electrode, Au was deposited on top of the samples using thermal resistance evaporation to define an active device area of 0.20 cm^2. To compare the TiO_2/YD2/P3HT based devices to devices without the benefit of the panchromatic light absorption, two types of control devices were prepared. First TiO_2/P3HT devices were prepared as above, but without the YD2 dye. Also, a YD2 sensitized TiO_2 device with the transparent HTM, Spiro-OMeTAD, was assembled under optimized conditions as previously described.[5] In this case the mesoporous TiO_2 layer had a thickness of 2 µm

with 20 nm particles as this morphology has been found to give the highest performance in Spiro-OMeTAD based devices.

Additional experimental details:

Device characterization: The incident photon-to-current conversion efficiency (IPCE) was created by using the incident light from a 300 W xenon lamp (ILC Technology, U.S.A.), which had been focused through a Gemini-180 double monochromator (Jobin Yvon Ltd.). The irradiation source employed for the *J-V* measurments was a filtered (Schott 113) 450 W xenon light source (Osram XBO 450, USA) whose power was adjusted using a reference Si photodiode equipped with a color-matched filter (KG-3, Schott), thus reducing the spectral mismatch between the simulated light and AM 1.5G irradiation in the region of 350–750 nm to less than 4%.

PL Measurments: To probe efficient electron transfer from P3HT to YD2, photoluminescence (PL) measurements were performed using a time-correlated single photon counting (TCSPC) system from PicoQuant. Films were excited with a pulsed laser diode, (model LDH 485: 481nm, 70ps FWHM, 5MHz) detected with a single photon avalanche diode (PDM 100CT SPAD) attached to a monochromator and processed by a PicoHarp 300 correlating system. For the PL measurements we deposited the pristine P3HT and the P3HT/YD2 (P3HT:YD2=20:1 concentration ratio) in an inert poly(methyl methacrylate) (PMMA) matrix on a glass substrate using a spin coater.

References:

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2. K. M. Coakley and M. D. McGehee, *Appl. Phys. Lett.*, 2003, **83**, 3380-3382.
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